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SECTION 4 - FINAL DESIGN

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CHAPTER III (cont.)

SECTION 4 - FINAL DESIGN

4.0. Final Design Submittal. The Final Design submittal shall consist of the following documents:

- |                  |   |
|------------------|---|
| required by      | ◦ Design Analysis                           |
|                  | ◦ Drawings                                  |
|                  | ◦ Typed Specifications                      |
|                  | ◦ Marked-up Guide Specifications            |
|                  | ◦ Cost Estimate                             |
|                  | ◦ DD Form 1354 Data Sheet                   |
|                  | ◦ Completed Environmental Permit Matrix (if |
|                  | the scope of work)                          |
| Instructions for | ◦ Final Engineering Considerations and      |
|                  | Field Personnel Report                      |
| Work             | ◦ Other Items as Required by the Scope of   |

The designer must include the requirements of SECTIONS 1, 2 and 3 in the Final Design documents whether or not any previous submittals were required. This chapter will define, by discipline, requirements of the Design Analysis and the Drawings. The specific requirements for preparation of the Typed Specifications and Marked-up Guide Specifications are described in A-E Guide, Volume 3. The specific requirements for the preparation of the Cost Estimate are contained in A-E Guide, Volume 2. A-E shall also refer to Chapter 2, "Presentation of Data" of this guide for design analysis format and drawing format and quality requirements. See appropriate Appendix of this volume for Environmental Permit Matrix and Engineering Considerations and Instructions for Field Personnel Report requirements.

4.1. Objective. The final submittal represents 100% of the design effort and is intended to present a biddable, constructable and operable design package, conforming to all the appropriate criteria. Final design will be accomplished by developing and refining the design as presented in the previously prepared submittal(s) (Concept, Early Preliminary, Preliminary as applicable) and as modified by

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the review comments.

4.2. Changes To Basic Design. Major changes to the basic design will not be permitted at this time, unless these changes are the result of review comments, changes in criteria, changes in scope of work, or unforeseen problems necessitating the A-E to alter his original design. All the changes shall be resolved through the COE PM before proceeding. If major changes have been made since the last submittal, such changes shall be identified and described in the design analysis.

4.3. Design Analysis - General Requirements. The Design Analysis prepared for previous submittals shall be expanded and refined into final form to contain that required by SECTIONS 1, 2 and 3 of this chapter plus requirements contained herein.

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4.4. Drawings - General Requirements. Expand and fully develop drawings required by Sections 1, 2, and 3 of this Chapter adding new drawings as necessary to meet the requirements stated hereinafter. Include in the drawings, all plans, elevations, sections, wall penetrations, furred spaces, duct and pipe chases necessary for mechanical and electrical systems. Consider spacing of required off-sets of beams, girders, reinforcing steel, joists and truss members. Where space is tight, show unequivocally that the systems will fit the space provided. Particular attention shall be paid to areas of duct branches and cross-overs. Close coordination between all designers shall be accomplished to avoid conflicts between the various disciplines' drawings. Whenever Additive or Deductive Bid Items are required, the limits of work or scope of these items shall be well defined on the respective disciplines' drawings and clearly defined by word description in the specifications. (See A-E Guide, Volume 3, Specifications, for bid schedules). Make sure adequate details are provided to cover those situations where additive bid items are not awarded such that the drawings present a complete design without the additive bid items.

4.5. Civil Design.

4.5.1. Design Analysis - Narrative. Complete the discussion of civil features that was presented in the Concept, Early Preliminary, or Preliminary submittals. Update the narrative to include any changes brought about as a result of review comments.

4.5.2. Design Analysis - Calculations. See Preliminary submittal requirements. Update the calculations to include any changes required by review comments.

4.5.3. Drawings. Expand and fully develop drawings used in Concept, Early Preliminary or Preliminary submittals. Add any new sheets necessary to complete the presentation, including the following:

4.5.3.1. Topography: Provide topographic sheet(s) showing the existing site conditions.

4.5.3.2. Demolition Plan. The demolition plan shall indicate all existing structures, foundations, and

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pavements, including type, dimensions, and thickness, which will require demolition and removal prior to the project construction. All existing utility lines to be removed or abandoned in place, and all existing trees and shrubs to be removed or saved, shall be indicated, dimensioned, and depth requirement established for all foundation removal. Buried tanks that are not to be completely removed, but abandoned in place, shall be filled with sand. Photographic reproductions of complicated buildings for structures to be demolished may be used to supplement drawings and notes for clarity. Demolished and removed material shall be clearly indicated as going to an existing dump area on the Base, or hauled and deposited off of the base. Material to be salvaged shall be identified and direction given by notes as to how and where it shall be stored or deposited. This specific direction shall be obtained from the BCE through the COE PM. Asbestos and other hazardous materials at the site shall be identified and a safe removal/disposal plan developed.

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4.5.3.3. Siting: Show the dimensions of all new work and the relation of new work to existing facilities. The new work will be located by coordinates or other definite means. Only one bench mark will be used except where a very large area is involved. Indicate the bench mark location, elevation, and description. Provide a north arrow and at least two horizontal control points. For airfields, this information must be shown for each separate area of pavement. Clearly locate on-base borrow and spoil areas. Indicate possible future construction using short dashed lines.

4.5.3.4. Grading: Provide a north arrow and show the grading and drainage conditions including swales, direction of drainage, point of discharge, and ditches using notes, symbols, and spot elevations or contours. Provide finished grades for new work and show existing topography. Provide sections showing the relationship between existing ground and finished grades, pavements, shoulders, ditches, swales, curbs, gutters, buildings and other structures. Provide a minimum of one cross-section in each direction through a building and site development area.

4.5.3.5. Plan, Profile, and Sections: Provide plan and profile for roads, runways, taxiways, channels, and other work that requires longitudinal layout and grade controls. The drawings shall include the new features and alignment superimposed on existing topography. Show stationing and finished grades at 100-foot intervals with intermediate points as required by vertical and horizontal curves and other features. Drawing sheets may be either single or double plan and profile. Provide cross sections at 100-foot intervals, or less, as required by topography and grading. Cross sections can be included in contract documents or as a supplement to the plans. Channel cross sections shall show the design flow elevation.

4.5.3.6. Railroads: Show the location and dimensions of all railroad tracks and features. Provide details showing switches, turnouts, and road crossings. Include all elements of the track section with depth and compaction requirements for the ballast construction.

4.5.3.7. Paving, and Fencing: Show the location and dimensions of all roads, streets, walks, pads, open storage

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areas, runways, aprons, taxiways, over-runs, fences and gates. Do not show fence lengths on plan sheets for Lump Sum Bids (See Specification, A-E Guide Volume 3). Indicate different surfaces and pavement sections with symbols and notes. Provide details showing joints, curbs, gutters, signs, sealants, sidewalks and pavement sections. For rigid pavements spot elevations shall be provided at each joint intersection. Include all elements of the pavement with depths and compaction density requirements. Clearly show joint layout, thickened edges (where required), location of tie-down anchors, markings and striping. Provide details of parking stalls, handicap parking symbols and signs and traffic signs. Provide a separate signing and striping plan where extensive work of this nature is required.

4.5.3.8. Utilities. Provide the following:

a. Show sizes of all existing and new lines (such as water, sewer, storm drain, gas lines, compressed air lines, nitrogen lines, etc.). Also show all valves, manholes, fire hydrants, service boxes, inlets,

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culverts, headwalls and cleanouts. Call out existing pipe materials if such information is available. Provide a north arrow on the utilities site plan and show the relation between the utilities and roads, buildings, sidewalks, etc. Provide the sizes, strengths or classes corresponding to the different material options. Indicate the invert elevations and points of entry to buildings for utility lines. Do not show lengths of utility runs on plan sheets for Lump Sum Bids (See A-E Guide, Volume 3).

b. Profiles shall be provided for wastewater collection lines, storm drain lines, force mains, water supply and distribution lines and petroleum lines where there is a possibility of interference with other utilities. Show existing topography on both Plan and Profile. Profiles will also be provided to show adequate cover in areas of varying topography. The profiles shall show minimum cover and required excavation and backfill depths, new and existing utilities, invert elevations, stationing, surface features such as roads, curbs, sidewalks, etc., and appurtenances to the utility system.

c. Furnish details of all features such as valves, manholes, fire hydrants, service boxes, inlets, headwalls, cleanouts, thrust blocks, pipe encasements, frames, grates, covers, steps, etc. For treatment facilities provide details for treatment units. Show all in-plant lines and process piping. In congested areas or in areas where data is unclear as to the exact location of utilities, the utilities drawings should contain the following note:

"Elevations of utilities are given to the extent of \_\_\_\_\_ information available. Where elevations are not given at \_\_\_\_\_ points of existing utilities crossings, such elevations shall be determined by the Contractor and reported to the \_\_\_\_\_ Contracting Officer. When unknown lines are exposed, \_\_\_\_\_ their location and elevation shall likewise be reported."

d. Miscellaneous Details: The A-E shall utilize details contained in the Standard Details for Utilities, Foundations, Paving and Railroads (provided to

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A-E in Basic Design Criteria Package) as appropriate for items described above.

4.6. Landscaping Design.

4.6.1. Design Analysis - Narrative. Complete the discussion of the landscape treatment that was presented in the Concept, Early Preliminary and/or Preliminary submittals. Update the design analysis to include any changes brought about by review comments. If no landscaping is required, so state.

4.6.2. Design Analysis - Calculations. Provide all calculations used for determining pipe sizes, type of sprinkler head in regards to area of coverage and number of heads per valve. Define water pressure used in analysis and state how that value was determined.

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4.6.3. Drawings.

4.6.3.1. Landscaping Plan. Show exact location of each plant, with a connecting line to plan symbol indicating type of plants and number of plants. Show exact location of construction features, i.e., benches, mowing strips, drainage ways, header boards, fences, retaining walls, garden structures, planters, pathways, walkways, service and refuse areas. These features are to be detailed on the landscaping plan sheets.

4.6.3.2. Planting details and sections. Details and sections required to define the work are to be drawn to a scale of 1/2" = 1' -0" minimum or as approved by the COE.

4.6.3.3. Planting schedule. Provide a plant schedule to include the following:

- a. Common name.
- b. Botanical name.
- c. Quantity of each variety planted.
- d. Height after planting.
- e. Container size and kind of container space pattern. Tree size should be a minimum of 15 gallons to improve survivability.

4.6.3.4. Irrigation Plan. The irrigation plan shall be drawn on a separate sheet. Show all irrigation lines, spray heads and drip emitters. Show coverage of each spray head on the drawing. Show pipe sizes, control valves, vacuum breakers and point of connection to water distribution system. Show mechanical appurtenances necessary for the proper function of the system. Each item will be indicated by an appropriate symbol. Indicate each kind and size of pipe by symbol. Provide a table indicating types of spray heads and drip emitters, diameter of coverage, gpm and minimum psi required at each head. Indicate total water requirement and pressure required for the system.

4.6.3.5. Irrigation schedule. Provide an irrigation

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schedule to include the following:

- a. Type and size of head, gallons per minute (gpm), pressure in pounds per square inch (psi) required and radius.
- b. Type and size of drip emitter.
- c. Type and size of valve.
- d. Type of controller.
- e. Type and size of pipe.
- f. Type of backflow preventor.
- g. Method of tap.

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4.6.3.6. Irrigation Details. Other details shall be added as necessary to clearly show the work to be done. Irrigation details and sections are to be drawn to a scale of 3/4" = 1' -0" minimum or as approved by the COE.

4.7. Architectural Design.

4.7.1. Design Analysis - Narrative. Complete the discussion of architectural features presented in the Concept, Early Preliminary, or Preliminary submittals. Update the narrative to include any changes brought about by review comments.

4.7.2. Design Analysis - Calculations. Update the floor area calculations IAW Plate 16, Chapter IV, to reflect changes brought about by review comments and/or floor plan changes.

4.7.3. Drawings. Expand and fully develop drawings used in Concept, Early Preliminary or Preliminary submittals. Add any new sheets necessary to complete the presentation, including the following:

a. Caulking joint shapes: Make sure the appropriate joint shapes are included in the caulking and sealant guide specification. Do not duplicate these shapes on the drawings.

b. Finish and colors: Complete for each space by use of "Finish Schedule, Finish Legend and Color Schemes" (see Plates 10, 11, 12, and 13, Chapter IV). Include color of factory finished materials (e.g., floor tile) for all interior finishes and for all building exterior finishes.

c. Door opening schedule: This shall follow sample format indicated on Plate 8, Chapter IV.

d. Window schedule: This shall follow sample format indicated on Plate 9, Chapter IV.

4.7.4. Color Boards. See prior submittal requirements. Update as necessary based on review comments.

4.8. Structural Design.

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4.8.1. Design Analysis - Narrative. Complete the discussion of structural features that was presented in the Concept, Early Preliminary, or Preliminary submittals. Update the narrative to include any changes brought about by review comments.

4.8.2. Design Analysis - Calculations. Present complete structural calculations covering all parts of the structure and miscellaneous facilities.

4.8.2.1. Design methods shall be described, including assumptions, theories, and technical formulas employed in design solutions.

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4.8.2.2. Live loads shall be placed to produce maximum stresses and minimum stresses where there is a possibility of stress reversal.

4.8.2.3. If special methods of solution, tables, etc., are employed, references should be made in the calculations to the sources of such material.

4.8.2.4. For addition/alteration type projects, provide calculations necessary to verify adequacy of existing structure to support new functional loads or to satisfy any new loading criteria.

4.8.2.5. When a computer is utilized to perform design calculations, the analysis shall include copies of computer input data and output summaries presented in understandable language, accompanied by diagrams which identify joints, members, areas, etc., according to the notations used in the data listings. This will form an integral part of the design analysis in lieu of manual calculations otherwise required. A complete listing of all computer output will be provided in a separate binding when it is too voluminous for inclusion in the design analysis. These listings will be augmented by intermediate results where applicable, so that sufficient information is available to permit manual checks of final results.

4.8.3. Drawings. Expand and fully develop drawings used in Concept, Early Preliminary or Preliminary submittals. Add any new sheets necessary to complete the presentation.

4.8.3.1. The structure should be carefully studied so that elaborate details are not required and all information necessary for construction is clearly and simply presented on the drawings. Typical sections shall be truly typical and not representative of one particular condition.

4.8.3.2. Wall Elevations: Wall elevations shall be provided for precast or tilt-up concrete panels, showing typical reinforcing, reinforcing around openings, connections, etc. The intent is to show one complete design on the drawings, even though manufacturers may prefer to detail things differently.

4.8.3.3. Joints: The location and details of all

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joints shall be shown on the drawings. Include control joints in slabs-on-grade, construction joints in walls, floors, roofs, and expansion and seismic joints.

4.8.3.4. Structural data: State the soil bearing values and other pertinent information from the geotechnical report, design live loads for various areas of the building; design wind load; seismic zone; Z, I, K, C, S values, whether or not the building has been designed for future horizontal or vertical loads; and any other notes necessary to clarify or complete the information shown on the drawing.

The COE or A-E prepared geotechnical report shall not be referenced because it is not part of the contract documents.

Check all general structural notes for conflicts with the specifications. The notes should not repeat the specifications. All structural data shall appear on the first sheet of the structural drawings.

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4.9. Mechanical Design.

4.9.1. Design Analysis - Narrative. Complete the discussion of Mechanical features that was presented in the Concept, Early Preliminary, or Preliminary submittals. Update the narrative to include any changes brought about by review comments.

4.9.2. Design Analysis - Calculations.

4.9.2.1. Finalize all calculations leading to sizing of distribution systems, selection of equipment, power requirements, controls, and selection of auxiliary equipment.

4.9.2.2. Equipment selection is restricted to regularly cataloged items of domestic manufacture, in commercial service for more than one (1) year, and supplied by dealers having service organizations supporting the project location. Completely identify each piece of equipment with three manufacturers' names, model numbers, and characteristics in the design analysis. Do not use proprietary names and model numbers on the drawings or in the specifications.

4.9.2.3. Provide complete tabulation of cooling loads. Psychometric charts for all the air handling systems with cooling are required. In addition, update building block load cooling calculation summary on AF Form 108 (See Chapter IV, Plate 19) "Air Conditioning Load Estimate." If a computer load simulation program was used, transfer the appropriate data and results from the computer print-outs onto the form.

4.9.3. Drawings. Expand and fully develop drawings used in Concept, Early Preliminary or Preliminary submittals. List room names and numbers on all plans and partial plans as shown on the architectural plans. Add any new sheets necessary to complete the presentation, including the following:

4.9.3.1. Plumbing. Provide the following:

a. Show piping systems in two-dimensional riser diagrams for medical and dental facilities and for

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multi-story buildings.

b. Provide a schedule of plumbing fixtures and equipment.

4.9.3.2. Heating, Ventilating and Air Conditioning (HVAC). Provide the following:

a. Double line air distribution ducts will be required for all cross sections, elevations and in mechanical rooms. Single line ducts may be used for air distribution layout, provided sufficient cross sections are shown for congested areas, and for areas that are subject to potential structural interference.

b. If required for clarification of duct sizes and duct runs, show single line riser diagrams for supply, return, and exhaust air systems in multi-story buildings. Provide sections where needed to show special relations and indicate the typical location of lights, structural members, etc.

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c. Locate and detail all fire dampers.

d. Provide piping schematics to show all complicated flow processes.

e. Provide a sequence of operation and control description, and control system schematic diagrams on the drawings for all Mechanical Systems IAW AFR 88-15 and appropriate ETL's including ETL 83-1.

4.9.3.3. Fire Protection. Provide the following:

a. Minor fire protection work may be shown on the plumbing plan. Title block should indicate that the drawing is for both plumbing and fire protection.

b. Identify all sprinkled areas. Use different identification (symbols) for areas with different density (type of hazard). List each symbol with its pertinent hazard and density in the legend and symbols.

c. For detail of sprinkler riser see C.O.E. Standard Mechanical Detail Drawings. Normally, use drawing MFP-2 for wet pipe systems.

d. Show the riser locations on the plans.

e. Do not show sprinkler system layout, i.e. location of mains, branches, and sprinkler heads.

f. For Hydraulically Calculated Sprinkler Systems show the following information:

(1) Type of hazard.

(2) Minimum area of water demand (normally 3,000 square feet) (MIL-HDBK-1008).

(3) Minimum rate of water application (density) GPM/Sq. ft.

(4) Any special sprinkler head temperature rating or classification.

(5) Minimum hose stream requirements.

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(MIL-HDBK-1008).

(6) Fire Hydrant location and flow data including static and residual pressures (normally listed in design analysis and/or shown on Civil Drawings).

4.9.3.4. Energy Monitoring and Control System (EMCS). Provide the following:

a. Provide schematic diagrams, input-output (I/O) summary schedule, and legend and symbols list as per AFR 88-15/AFM 88-36.

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b. The EMCS schematic diagrams shall be separate from, and in addition to, the controls systems diagrams as described above in subparagraph 4.9.3.2.e.

c. The designer is required to coordinate selection of points to be monitored with the using agency when completing the I/O summary schedule.

4.10. Electrical Design.

4.10.1. Design Analysis - Narrative. Complete the discussion of electrical features that was presented in the Concept, Early Preliminary, or Preliminary submittals. Update the narrative to include any changes brought about by review comments.

4.10.1.1. Describe any special switching or dimming systems required for any area.

4.10.1.2. Provide rationale for selection of reduced-voltage starting equipment.

4.10.1.3. Provide an energy impact analysis.

4.10.2. Design Analysis - Calculations.

4.10.2.1. Provide complete design calculations for all interior and exterior electrical systems.

4.10.2.2. Provide manufacturers' names and model numbers for each major piece of equipment used in determining dimensional and weight requirements. Do not use proprietary names and model numbers on the drawings or in the specifications. See Chapter 1, para. 7.0, and A-E Guide Volume 3.

4.10.3. Drawings. Expand and fully develop drawings used in Concept, Early Preliminary or Preliminary submittals. Add any new sheets necessary to complete the presentation.

4.10.3.1. Outside distribution system. Provide the following:

a. Overhead: Show location of new and existing poles, and routing of new lines on an

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electrical-only site plan. Indicate type and size of existing overhead conductors.

b. Underground: Show location of new and existing manholes and handholes on an electrical-only site plan. Locate and show details of major equipment. Show routing of ductline, ductline sections and detail of pole riser. Show adequate detail for complex grounding system (if applicable).

c. Area lighting: Show location of street, parking and walkway lighting poles. Provide details of luminaires, poles and bases. Details of luminaires shall only be provided when not covered by COE Standard Drawing No. 40-06-04.

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d. Floodlighting (on poles): Provide layout of lighting poles, showing dimensions and aiming angles.

e. Distribution System Profiles. For overhead and/or underground distribution projects over 2,000 linear feet in total length, profiles shall be furnished as described in paragraph 4.12g.(2).

f. Telephone Service Connection. Show the exterior telephone service point of connection.

4.10.3.2. Interior distribution system. Provide the following:

a. Floor Plan. Define the physical limits of each hazardous area and the class, division and group of equipment and wiring. Show conduit seals IAW NEC article 500. Show sizes of all conduits including conduit to be wired by others. Indicate number and size of conductors based on copper conductors. See AFR 88-15, Section A, paragraph 16-6 for aluminum conductor options. Provide a numbering system for all circuits. Detail seismic restraints for all electrical equipment. Show complete fixture, switch and receptacle arrangement, fixture details and identification of fixture type, special control equipment diagrams and complex switching diagrams. Indicate energy saving fluorescent fixtures with matched ballast and lamps. Provide fire rated recessed fluorescent fixtures to match fire rating of ceiling.

b. Single Line Diagram. Provide a one line or single line diagram (not a riser diagram) showing power service entrance location, major equipment and panel locations. State phase and voltage. Where required, show ground fault protection. Provide complete power receptacle arrangement, motor outlets, control diagrams and power equipment. For all electrical equipment list the performance characteristics required, complete schematic diagrams, and a written description of operation of complex control systems.

c. Panel Schedules. For panelboards, switchboards, power switchgear assemblies and motor control centers, provide total connected load, total spare load, main and branch circuit ratings, interrupting ratings, frame

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sizes for each circuit, number of poles, and description of each load.

d. Wiring Diagrams. Show a wiring diagram for each of the following systems on the plans: telephone, television, fire alarm, intercommunication, public address, and other required special systems. Show locations only of all antennas, service entrances, outlets and major equipment on a floor plan.

e. Airfield Lighting. Where airfield lighting is included in the project, show location, controlling dimensions, extent of the proposed system, routing of supply circuits, location of vaults and control towers, and locations for various types of lighting units.

f. Cathodic Protection. Where a cathodic protection system is included, show extent of the facilities to be protected, location and type of anode beds, location of test points, details for sectionalizing bonding and insulating (where applicable) an underground piping system, and source and routing of supply for impressed current.

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"There's never enough time to do it right,  
but there's always enough time to do it  
over."

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	g. <u>Generating Plant</u> . If the project includes a generating plant, provide a one line wiring diagram, fuel oil and coolant piping diagrams, equipment details and layout, and transfer controls in block form.	
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